NOTES ON ENTOMOSTRACA FROM COLORADO.

THE SHANTZ COLLECTIONS FROM THE PIKES PEAK REGION.

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The collections of entomostraca described in this paper were made by Dr. H. L. Shantz, mainly during the summers of 1903 and 1904. He made them the basis of a paper,[1] in which he gives a full description of the lakes, together with notes on various features of their fauna and flora. Full determination of the species of entromostraca in the collections were not, however, included in that paper. The collections have since been turned over to the United States National Museum, and at the request of the curator of marine invertebrates I have made determinations of the species. A number of the vials of the lot had dried, but there remained 169 vials of material in good condition, most of which contained entomostraca.

These collections are from two groups of lakes, one including nine bodies of water near timber line on the slopes of Pikes Peak, at elevations of 3,110 to 3,626 meters (10,200 to 11,890 feet) above sea level, the other 14 lakes and ponds on the plains, near Colorado Springs, just at the eastern base of Pikes Peak, at elevations of 1,800 to 2,203 meters (5,969 to 7,225 feet). It should also be noted that five of the lakes in the higher group were described by Ward [2] in 1904, the paper including a list of 13 species of entromostraca. This paper and the one by Shantz describe the region and the lakes so well that no further notes are needed in the present paper. The collections of Shantz should also be considered in connection with findings of the author in studies of entomostraca from both mountains and plains of Colorado, mainly from collections from the region of Boulder and Tolland, Colorado, about 65 miles north of Pikes Peak.[3]

Thirty-one species of entomostraca have been identified from the collections of Shantz, distributed as follows: Phyllopoda 1, Cladocera 19, Copepoda 11 species. For a detailed list of the species collected in each lake see Table 1. Three of these species have not previously been reported from Colorado, *Diphanosoma brachyurum*, *Ceriodaphnia*

[1] Shantz, H. L. A Biological Study of the Lakes of the Pikes Peak Region, Trans. Amer. Micros. Soc., vol. 27, pp. 75-98, with three plates, 1907.

[2] Ward, Henry B. A Biological Reconaissance of some Elevated Lakes of the Sierras and the Rockies, Trans. Amer. Micros. Soc., vol. 25, pp. 127-154, with 12 plates.

[3] Dodds, G. S. Descriptions of Two New Species of Entomostraca from Colorado, with Notes on Other Species, Proc. U. S. Nat. Mus., vol. 49, pp. 97-102, 1915; Altitudinal Distribution of Entomostraca in Colorado, Proc. U. S. Nat. Mus., vol. 54, pp. 53-87, 1917; Entomostraca and Life Zones, Biol. Bull., vol. 39, pp. 89-107, 1920.

quadrangula, and *Diaptomus washingtonensis*. The finding of *Diaptomus washingtonensis* here, at the eastern base of the Rocky Mountains, is of interest. The species was described by Marsh from material collected at Walla Walla, Washington, and its occurrence here is a long extension of range for a species of this genus, which is one composed of many species, most of which have rather limited range. It makes up an important part of the fauna of six lakes on the plains, but is not found in any of those in the mountains. There seems to be no doubt about the identification, as it bears all the marks by which Doctor Marsh distinguished it from *D. signicauda*, and agrees well with his figures and descriptions of material from the State of Washington.

The State of Colorado includes an area that has a far greater biological significance than might be expected of a mere political area. Situated as it is, astride the Continental Divide, it includes the highest portion of the Rockies, is the meeting place of eastern and western faunas, includes lowland areas of both the Great Plains and the Great Basin, and in its higher areas includes southern extensions of high northern faunas. It is thus a meeting place for faunas which under ordinary conditions are separated by hundreds of miles. The State includes portions of five life zones—Upper Sonoran, Transition, Canadian, Hudsonian, and Arctic-alpine. The collections of Shantz are of interest because they include a section through all of these zones with the very different climatic conditions prevailing at the extremes. It was with these conditions in mind that Shantz selected these lakes for study, as clearly indicated in the opening paragraph of his paper:

> Here, within a few miles of each other, are two groups of lakes representing quite different types, the alpine and those of the plains. The alpine lakes lie far up on the mountains, * * * with typical alpine surroundings. The plains lakes lie on the western edge of the Great Plains, * * * with conditions which are in no wise alpine. They are lowland lakes.

The species in these collections take on their greatest significance when considered in connection with the above facts, especially when considered in connection with my own collections from the Tolland region. It is hoped that the frequent reference to my own collections are made in such a way as to emphasize the importance of those made by Shantz, which, though made several years before I had done any collecting, unfortunately, were not determined, and so were deprived of the priority of notice to which they were entitled. Though they do not include by any means as many lakes as do mine, had they been studied soon after they were made they would have anticipated many of the facts presented in my earlier papers.

The species in these collections, just as did those from my own collections, fall into three natural groups, (1) 13 species found on the plains but not extending into the mountains, (2) 9 species found only

in the mountains, and (3) 9 species found in both groups of lakes. The third group includes the euthermic species, those which are able to live in both warm and cold water, while the first and second

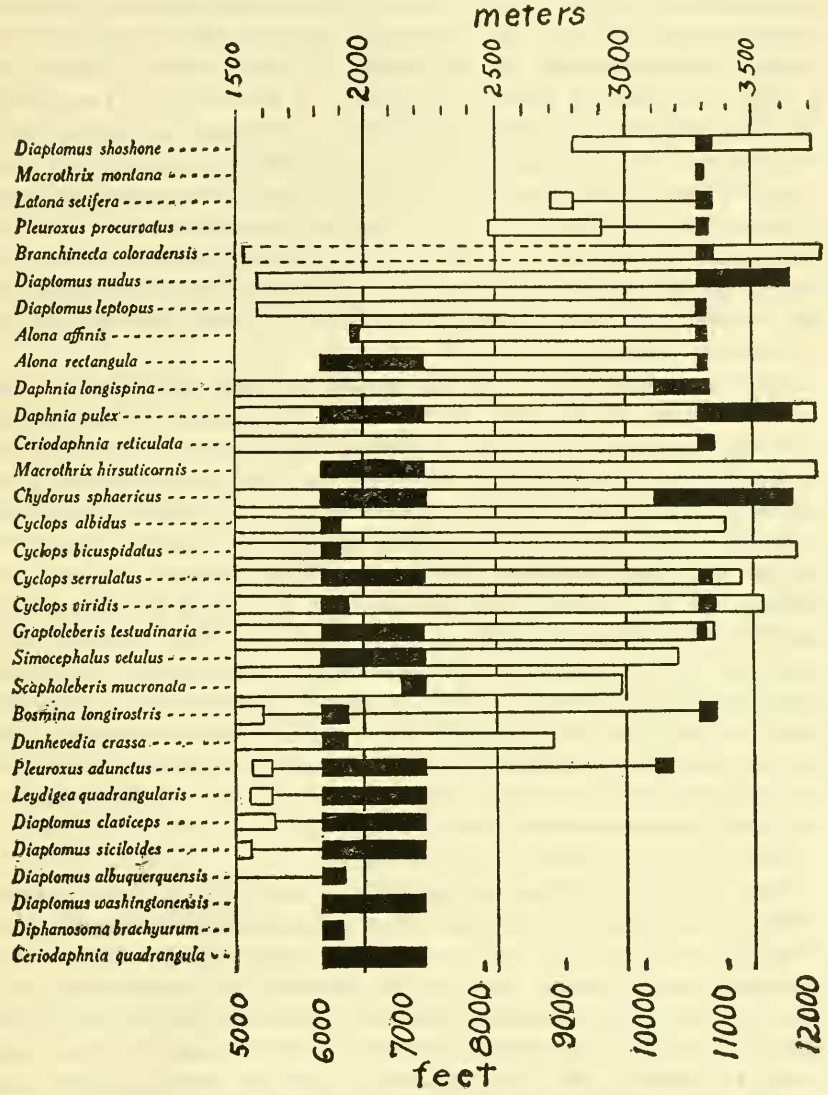

FIG. 1.—GRAPHIC REPRESENTATION OF ALTITUDINAL RANGE OF THE SPECIES OF ENTOMOSTRACA COLLECTED BY H. L. SHANTZ IN THE PIKE'S PEAK REGION. THE SOLID BLACK PART OF EACH BAR REPRESENTS THE RANGE OF ALTITUDE COVERED BY THE PRESENT COLLECTIONS, THE OPEN PART THE EXTENSIONS OF RANGE BY MAKING USE OF ALL OTHER RECORDS FROM THE STATE OF COLORADO.

groups are composed of stenothermic species, which are more narrowly limited to water of about the same temperature, the one group to colder waters, the other to warmer. These three groups are clearly shown in Figure 1. The significance of these records becomes

more apparent when we remember that these two groups of lakes are separated by but a few miles, the extremes of the two being separated by not more than 10 miles. Yet the two groups support entomostracan faunas quite distinct from each other, as distinct as if separated by hundreds of miles in a north and south direction, a fact which emphasizes the importance of an altitudinal difference of a little more than a thousand meters. It is commonly recognized that the entomostraca are a group in which dispersal is easy, as indicated by the cosmopolitan distribution of some species and the wide range of nearly all genera. Yet here, close together, we find two groups of lakes in each of which there are several species which are not found in the other. The several species common to the two groups stand in strong contrast to the others and serve to emphasize the fact that temperature may be an effective barrier for some species but not for others.

The zonal distribution of the species in these collections agrees well with that of the same species as found in the Tolland region. In a few instances the Shantz collections have served to extend the range of species into altitudes in which they had not previously been collected in the Colorado region, and in others they fail to give certain species as wide a range as assigned to them on the basis of collections in various other parts of the State. This, however, is not surprising. The gratifying thing is the large extent of the agreement, and the few differences are not surprising in view of the relatively small amount of the work that has been done in this as well as in other parts of the State. It is of interest to remember, also, that the lakes on the plains are artificial, that the oldest was only 28 years old at the time Shantz made his collections, and that most of them are far younger than that, and that even the youngest of them had an abundant entomostracan fauna (as Mesa No. 3, which was only 1 year old and yet yielded eight species).

The lakes of the higher group fall into two divisions on the basis of their fauna, and these two divisions have an altitudinal significance. Dead Lake, which falls within the Husdonian or upper part of the Canadian zone, typifies the highest division and agrees well with the 43 lakes and ponds in the Tolland region assigned to the Alpine Zone (Dodds '17). In the 22 vials of material from this lake there were 11 species. By far the most abundant among them were *Daphnia pulex* and *Diaptomus shoshone*, the two species which characterize the highest lakes of the Tolland region. *Branchinecta coloradensis*, another typically alpine form,[4] is also present. Certain

[4] Shantz, H. L. Notes on the North American Species of *Branchinecta* and their Habits, Biol. Bull., vol. 9, pp. 249-264, 1905.

Branchinecta coloradensis has been considered an exclusively alpine species, but if the record as determined by the author from a collection sent him from St. Vrain, Colorado, at 1,525 meters (5,000 feet), May 30, 1912, be correct, our notions on this must be revised. The author invites comment on this and would be glad of additional material bearing on this point. (See Dodds '17, p. 77.)

of the other species from this lake have also a significance as belonging to mountain lakes, but none of them are definitely related to the alpine zone as distinct from other mountain elevations. Bald Mountain Lake, 52 meters above timber line, doubtless also belongs to the alpine zone, but its fauna, as represented in the collections, is too scant to be of significance, except for the presence of *Daphnia pulex*.

Michigan Lake, 288 meters below timber line, while at nearly the same elevation as Dead Lake, has a decidedly different fauna, one which relates it to a lower zone in agreement with the 63 lakes of the Tolland region assigned to the Montane (probably Canadian) zone. In this lake are found as the dominant species *Daphnia longispina* and *Diaptomus leptopus*, var. *piscinae* in place of the two species of these genera found in Dead Lake. In two other lakes, Heart and Fish, this is also the case, while in Ribbon Lake these two species are also very abundant with a few individuals of *Daphnia pulex* in one of the collections. It has been shown clearly in the Tolland region that *Diaptomus shoshone* belongs to a higher group of lakes than does *D. leptopus*, var. *piscinae*, and though no very definite altitudinal difference is apparent in the Pike's Peak group, probably because the number of lakes is few and they are at not greatly differing altitudes, it is quite probable that the same significance attaches to these two species here as in the Tolland region. In making studies of altitudinal zonation it is a striking fact that local conditions often change the biotic conditions, so that zonal boundaries are ragged. In the Tolland region, while the two species of *Diaptomus* did unquestionably belong to two different altitudinal regions, there were a few scattered lakes containing *D. shoshone* well within the area occupied in the main by *D. leptopus*. It was also a striking fact in the Tolland region that in mountain lakes where *Diaptomus shoshone* was present the species of *Daphnia* present was *pulex*, and that when *Diaptomus leptomus* was present, *Daphnia longispina* rather than *pulex* was present. In hardly any instance were both species of *Diaptomus* found in the same lake nor both species of *Daphnia*. The collections of Shantz show the same relations to exist in the Pike's Peak lakes between these four species. They have been selected as "zone indicators" because when present in a lake they are usually there in considerable numbers and because they appear to give a consistent separation between zones.

Other species of significance in the mountain group of lakes, as belonging to mountain rather than to lowland lakes, though not of use in differentiating between the zones within the mountains, are *Macrothrix montana* (described by Birge from Pike's Peak material and so far not reported from other localities), *Latona setifera*, *Pleuroxus procurvatus*, and *Diaptomus nudus*, which belong to the colder zones,

either in northern latitudes or in higher elevations of more southern regions.

The lakes on the plains, as previously mentioned, have several species in common with those in the mountains, but they lack those just mentioned as belonging especially to the mountains. In addition they have several species which do not extend into the mountains at all, but are common forms in lowland lakes. Conspicuous among these are four species of *Diaptomus*, which, both on account of their size and their numbers, constitute an important part of the entomostracan fauna. *Diaptomus claviceps* and *D. washingtonensis* are found in abundance in five lakes, while *D. siciloides* and *D. albuquerquensis* are plenty in certain others. It would be of interest to have collections from other lakes in this region to determine whether these four species are commonly associated in these two groups, and if possible to determine the underlying conditions. *Daphnia pulex* is commonly present in these lakes, but *D. longispina* was not collected, the findings again agreeing with common conditions in the plains portion of the State. The other species do not call for special comment.

In regard to amount of entomostracan life, there is some advantage, though not great, with the lakes on the plains. The mountain lakes are by no means scant in species or in individuals, nor is the size of the individuals less than in the warmer lakes. I have made no attempt to compare in detail the fauna of the different lakes. Points of interest might appear in such a study, but it appears that the greatest interest of these collections is their relation to altitudinal zonation and their bearing upon this problem as it has been studied at other points in the same general region.

TABLE 1.—*List of lakes, elevation of each, number of collections from each, and number of collections in which each species was found.*

Name of species.	Name of lake.																						
	Bald Mountain Lake.	Dead Lake.	Ribbon Lake.	Small Lake below Ribbon.	Michigan Lake.	"Beyond Michigan."	Moraine Lake.	Heart Lake.	Fish Lake.	Palmer Lake.	Monument Lake.	Mesa I Reservoir.	Mesa II Reservoir.	Mesa III Reservoir.	Becker's Reservoir.	Stratton Lake I.	Stratton Lake II.	Colorado Spring Bridge.	Prospect Lake.	Boulder Reservoir.	Little Boulder.	Portland Reservoir.	Jenk's Pond.
Elevations, in meters	3,625	3,350	3,290	3,290	3,285	3,285	3,110	3,292	3,285	2,228	2,100	2,000	2,000	2,000	1,950	1,889	1,889	(?)	1,830	1,829	1,829	1,820	1,800
Branchinecta coloradensis Packard	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Latona setifera (O. F. M.)	.....	1	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Diaphanosoma brachyurum (Lieven)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Daphnia pulex DeGeer	1	10	1	.....	.....	.....	1	.....	.....	2	.....	1	3	6	.....	.....	.....	.....	2	2	.....	1	.....
Daphnia longispina O. F. M.	.....	.....	6	.....	3	.....	.....	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	3	2	5	.....
Scapholeberis mucronata (O. F. M.)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Simocephalus vetulus (O. F. M.)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ceriodaphnia reticulata Jurine	.....	.....	1	.....	5	1	.....	.....	.....	.....	1	.....	1	.....	.....	.....	.....	.....	1	2	4	1	.....
Ceriodaphnia quadrangula (O. F. M.)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Bosmina longirostris (O. F. M.)	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	2	3	.....
Macrothrix hirsuticornis N. and B	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2	.....	1	.....	.....	2	2	.....	.....	.....
Macrothrix montana Birge	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....
Graptoleberis testudinaria (Fischer)	.....	1	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
Leydigea quadrangularis (Fischer)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....
Alona rectangula Sars	.....	2	.....	.....	.....	.....	.....	.....	.....	1	1	.....	1	.....	1	.....	1	.....	1	8	2	.....	.....
Alona affinis Leydig	.....	3	.....	1	.....	.....	.....	3	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
Dunhevedia crassa King	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	3	.....	.....
Pleuroxus procurvatus Birge	.....	.....	.....	.....	4	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pleuroxus aduncus Jurine	.....	.....	.....	.....	.....	.....	1	.....	.....	1	.....	.....	2	1	.....	.....	.....	.....	.....	4	1	.....	.....
Chydorus sphaericus (O. F. M.)	2	8	4	1	4	.....	1	1	5	2	.....	.....	2	2	.....	.....	2	.....	.....	2	3	4	.....
Diaptomus shoshone Forbes	.....	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Diaptomus albuquerquensis Herrick	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Diaptomus siciloides Lilljeborg	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	.....	.....	.....	.....	.....	.....	.....	6	3	.....	1
Diaptomus nudus Marsh	1	4	.....	.....	2	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	6	2	.....	.....
Diaptomus claviceps Schacht	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	3	4	2	.....	.....	.....	.....	.....	.....	.....	2	.....
Diaptomus leptopus, var. *piscinae* Forbes	.....	.....	6	.....	4	.....	.....	6	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Diaptomus washingtonensis Marsh	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	3	5	7	.....	.....	.....	.....	.....	.....	.....	4	.....
Cyclops albidus Jurine	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
Cyclops bicuspidatus Claus	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	1	.....
Cyclops serrulatus Fischer	.....	.....	.....	1	7	.....	.....	.....	.....	.....	.....	.....	1	.....	1	.....	.....	1	1	.....	.....	1	.....
Cyclops viridis Jurine	.....	2	3	.....	4	1	.....	2	.....	1	.....	.....	.....	.....	1	.....	2	.....	4	7	.....	.....	.....
Number of collections from each lake	5	22	15	2	10	1	7	12	10	3	1	4	8	10	4	2	2	1	8	9	4	11	2